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Description

The present invention relates to an integral textile composite fabric of non-woven, needled textile fibers, and more particularly to such a composite having at least one organic textile fiber layer and at least one glass fiber layer where the layers are substantially non-detachable from each other and where the organic fiber layer is essentially free, at least on its outer surface, of glass fibers from the glass fiber layer.

Background of the invention

Needled textile fabrics are normally composed of synthetic organic textile fibers, e.g. polyester, nylon, acrylic, etc., or other synthetic organic fibers, needled together into a consolidated mat. While such fabrics may also be made of natural organic fibers, e.g. cotton, hemp, wool, etc., these natural fibers are capable of being formed into a non-woven fabric of substantial properties by the more traditional process, e.g. felting, and hence, are not usually needled to form a non-woven fabric. Inorganic fibers, on the other hand, and especially glass fibers, are not normally either felted or needled, but are consolidated into a fabric of, generally, low physical properties by an air lay or wet lay process. This is because inorganic fibers, by virtue of the materials and process of producing, have very little crimp therein, are of high modulus and substantially brittle, all of which do not lend the inorganic fibers to being either carded, needled or felted. U.S. Patent 3,608,166, for example, details the difficulties in needling glass fibers. Limited needling has been done, however, for the purpose of lightly tacking a glass fiber batt.

U.S. Patent 3,338,777 teaches that the ability to needle glass fibers can be improved by crimping those fibers, but this is quite unacceptable from a commercial point of view because of the cost thereof.

Thus, most needled fabrics, being composed generally of synthetic organic fibers, find a variety of applications where relatively high physical properties are required, e.g. high strengths, with substantially uniform physical properties in both the longitudinal and widthwise direction, and particularly in those applications where economics dictate the use of materials less expensive than woven fabrics or where the applications require more uniform thickness direction properties than woven fabrics, e.g. as a filter media or as a heat insulator. However, since such needled fabrics are generally restricted to synthetic organic fibers, the application of these needled fabrics has been substantially limited when higher temperatures are involved. In addition these needled fabrics have also been limited in applications where filtration requirements are such that the synthetic organic fibers are not f sufficiently small denier to achieve high particulate filtration. Thus, the normal needled fabrics suffer from considerable disadvantages in these regards.

The art has attempted to overcome these disadvantages by use of a number of different approaches, in one approach, high temperature and finer denier synthetic organic fibers have been used to produce the needled fabric, but this solution results in only improved properties, based on the properties of the fibers used, and does not avoid the difficulties associated with the use of synthetic organic fibers, as explained above. For example, the finest denier synthetic organic fiber commercially available in the United States is 1.5 denier (0.16 tex). In addition these high temperature and finer denier organic fibers are expensive and their use cannot be accepted in many commercial applications.

Another approach in the art, as exemplified by U.S. Patent 3,338,777, has been that of mixing together organic fibers and glass fibers. Such a mixture of fibers significantly improves the ability to needle the glass fibers into a consolidated fabric of reasonable physical properties. However, this approach suffers from the disadvantage that the mixture of organic fibers and glass fibers decreases the resulting physical properties of the resulting fabric, as opposed to an all organic fiber fabric, due to the increased difficulty of needling the glass fibers into a fabric of high strengths. In addition this approach does not solve the filtration problem. For example, finer particulate filtration is achieved when there is provided a relatively homogeneous layer of finer diameter fibers, e.g. glass fibers, than when such a layer is a mixture of such finer diameter fibers and large diameter fibers, e.g. conventional synthetic organic fibers.

Aside from the foregoing difficulties in resulting properties, a needled mixture of organic fibers and glass fibers has recently been determined to have a most undesired health problem. In needling the mixture, glass fibers may be disposed throughout the thickness of the needled fabric, and including the surfaces thereof. The co-needling of the organic fibers and glass fibers, nevertheless, breaks many of the low stretchable and brittle glass fibers. These very small broken glass fibers are easily displaceable from the surface of the fabric when the fabric is in use and the displaced broken (as well as unbroken) glass fibers will freely float in the air. If workers inhale these broken glass fibers, serious lung damage can result. Accordingly, for safety sake, use of such fabrics is considerably discouraged, or even prohibited, in many industries.

None of the above approaches in the art have produced satisfactory results, and, generally speaking, needled fabrics are only normally composed of organic synthetic fibers, and these fabrics have limitations on their application, as explained above.

An attempt at a different approach is disclosed in U.S. Patent 3,608,166, where organic fibers are used to needle "connecting" fibers through a glass fiber mat, preferably reinforced with a woven fabric, but that patent recommends oiling the glass fibers to avoid the problem of breakage

and teaches using only about 12 to 15 needle punches per square centimeter. This is an unacceptably low number of n edle punches and the resulting needled mat has low strengths.

A somewhat related but different approach to that of U.S. Patent 3 608 166 is disclosed in U.S. Patent 3 975 565. That patent aims to overcome difficulties found in needling mats of polycrystalline inorganic fibers which tend to be laid down in laminar form and, to avoid delamination, are in more need of consolidation than are glass fibers. It proposes needle punching a mat of the inorganic fibers layered with a relatively thin web of organic fibers. It is however found in practice that, particularly with a higher number of needle punches per unit area (more than 41 per cm^2 (260 per in^2)), considerable breakage of the inorganic fibers can occur during needling. This both results in loss of strength and also constitutes a health hazard, as explained above in connection with needling mixtures of organic fibers and glass fibers.

Further, such a low number of needle punches is not capable of so needling the fibers as to produce uniform properties in the needled layers, since most of the fibers in the layers will retain the original laid orientation.

The present invention is based on the discovery that a needled fabric may be prepared by needling a composite batt prepared from a glass fiber batt and an organic fiber batt with needled punches of the composite batt being sufficient per unit area so that the batts are not readily detachable from one another, as more fully defined hereinafter, and where the needling takes place from at least the side of the composite batt having the organic fiber layer. The needling, however, must be carried out in a manner such that the glass fibers of the glass fiber batt are not substantially engaged by the barbs of the needles during the needling operation. With such lack of engagement, the needles can stitch organic fibers from the organic fiber batt into and through the glass fiber batt so as to bind the organic fiber batt to the glass fiber batt, while at the same time not substantially engaging, and, hence, breaking or displacing the glass fibers of the glass fiber batt. Stated another way, the needling is carried out in such a manner that the fibers of the organic fiber batt are needled into the glass fiber batt while the fibers of the glass fiber batt are left substantially undisturbed. By such a needling technique, high numbers of needle punches may be used in the process to form a highly needled and entangled organic fiber layer while at the same time not breaking or displacing the glass fibers of the glass fiber layer. The resulting composite fabric will have uniform and high physical properties due to the high amount of needling of the organic fiber batt. Also with such high amount of needling, the stitching of the organic fibers into and through the glass fiber batt will so bind the glass fiber and the organic fiber batts that they are essentially non-detachable, one from the other. Even further, since such needling will not substantially displace glass fibers from the glass fiber batt into the organic fiber layer batt, the resulting needled organic fiber layer will be essentially free, at least on the outer surface there f, of glass fibers. Thus, that surface avoids the h alth problem described above. Further, if the glass fiber batt is sandwiched between two organic fiber batts, and a similar needling takes place, from one or both sides of the sandwich, then again the resulting sandwiching organic fiber layers will not have glass fibers therein, at least on the outer surfaces thereof, and the entire resulting fabric will not pose the health problem described above.

The present invention thus provides a needled fabric made of a combination of a glass fiber layer and an organic fiber layer which can be needled to high numbers of needle punches per unit area, to achieve the physical properties discussed above, while at the same time not presenting a health hazard in use of such product.

According to the present invention there is provided an integral textile composite fabric of non-woven, needled textile fibers comprising:

(a) at least one organic textile fiber layer of laid textile organic fibers;

(b) at least one glass fiber layer of laid, uncrimped glass fibers;

(c) a plurality of first needled stitches binding the said layers together and composed essentially of said organic fibers from said organic fiber layer needled in and disposed substantially through said one glass fiber layer while the fibers of the said glass fiber layer are substantially undisturbed, and wherein said one organic fiber layer is essentially free, at least on the outer surface thereof, of glass fibers displaced from said one glass fiber layer.

Preferably, an additional organic fiber layer with an inner and outer surface is disposed with its inner surface adjacent the outer surface of the glass fiber layer and the stitches are also disposed in the additional organic fiber layer so that the additional organic fiber layer is likewise bound to the outer surface to the glass fiber layer, and hence, no glass fibers are present on either surface of the composite fabric.

This product is made by preparing a glass fiber batt of the glass fibers, an organic fiber batt of the organic fibers, placing the batts adjacent to each other to form a composite batt and needling the composite batt with preferably at least 109 needle punches per square cm (700 per sq. in.), more preferably 156 needle punches per sq. cm (1000 per sq. in.) in such a manner that the needles do not substantially engage the glass fibers of the glass fiber batt and where the needling is at least from the organic fiber batt.

For a better understanding of the invention and to show how the same can be carried into effect, reference will now be made, by way of example only, to the accompanying drawings, wherein:

Figure 1 is a diagrammatic illustration of a fabric according to the present invention composed of one organic fiber layer and one glass fiber layer;

Figure 2 is a diagrammatic illustration of the fabric of the invention composed of one glass fiber layer sandwiched between layers of organic fibers;

Figure 3 is a diagrammatic illustration of a filter made of the present fabric;

Figure 4 is a diagrammatic illustration of another filter made of the present fabric; and

Figure 5 is a diagrammatic illustration of a heat insulator made of the present fabric.

Detailed description of the invention

The invention can best be understood by first considering the diagrammatic illustrations of Figures 1 and 2 of the drawings. Both Figures 1 and 2 show an integral textile composite fabric of non-woven needled textile fibers. From Figure 1 it will be seen that the fabric 1 is composed of at least one organic textile fiber layer 2 of needled textile organic fibers 3, and the layer 2 has an inner surface 4 and outer surface 5. The fabric 1 also has at least one glass fiber layer 6 of glass fibers 7 and that layer has an inner surface 8 and an outer surface 9.

A plurality of first needled stitches 10 are composed essentially of organic fibers from organic fiber layer 2 and are needled in and disposed substantially through glass fiber layer 6 so that the layers are bound together at the respective inner surfaces 4 and 8. These stitches provide such binding of layers 2 and 6 that the layers are substantially non-detachable from each other and form an integral textile composite fabric. The amount of needling performed is also sufficient that the needled fabric has substantially uniform and high physical properties. To achieve these physical properties, there must be sufficient stitches per unit area passing through glass fiber layer 6. The number of stitches is preferably at least 109 per cm^2 (700 per in^2). It will also be noted from Figure 1 that the needling is such that organic fiber layer 2 is essentially free, at least on its outer surface 5, of glass fibers displaced from the glass fiber layer 6.

Organic fiber layer 2 and glass fiber layer 6 are needled from laid fibers. Fibers may be laid into a batt for needling purposes by a variety of known processes, including drafting, air laying, wet laying, and carding. However, it is most difficult to card glass fibers into a laid batt and the more conventional air laying of glass fibers is preferred. On the other hand, it is easy to card organic fibers into a laid batt and for that reason a carded layer of the organic fibers is preferred. In any event, the layers to be needled are laid layers and are to be distinguished from previously substantially consolidated (non-laid) layers, e.g. layers which may have been substantially consolidated by use of adhesives, thermal bonding and the like. This does not mean, however, that there can be no previous consolidation of the laid layers. For example, commercially available glass fiber batts may have a small amount of resin binder therein in order to provide sufficient strength for handling purposes. Nevertheless, the glass fibers of such batts are essentially free to move and are therefore considered to be a "laid" batt.

It is necessary that the layers be laid layers so that th pres nt needling of the organic fiber lay r may take place and the fibers of the glass fiber layer are sufficiently free to avoid engagement by the barbs of the needles. It will also be appreciated from the above that the laid glass fiber layer must also be of glass fibers which are not crimped, as disclosed in U.S. Patent 3,338,777, but conventional uncrimped laid glass fibers, and this is intended to be a part of the definition of "laid" glass fiber layer.

Referring now to Figure 2, it is preferable that the composite fabric 1 have an additional organic fiber layer 12. Again, layer 12 is of needled textile organic fibers 13, which may be the same or different fibers from that of layer 2, and that layer has an inner surface 14 and an outer surface 15. Layer 12 is disposed with its inner surface 14 adjacent to the outer surface 9 of glass fiber layer 6. The stitches 10 are also disposed in additional organic fiber layer 12 so that the additional layer is likewise bound to the outer surface 9 of glass fiber layer 6.

However, it is preferred that there is also a plurality of additional stitches 16, and again composed essentially of organic fibers from the additional organic fiber layer 12. Those stitches are needled in and disposed substantially through the glass fiber layer 6 so that the additional organic fiber layer 12 is bound to the glass fiber layer 6 at the outer surface 9 of the glass fiber layer 6 and the inner surface 14 of the additional organic fiber layer 12. This further provides that the glass fiber layer 6 and the additional organic fiber layer 12 are similarly substantially non-detachable from each other and an integral textil composite with all of layers 2, 6 and 12 is provided, which composite, again, has substantially uniform and high physical properties. The combination of first stiches 10 and additional stitches 16 should constitute the number of stitches per unit area required for adequate needling and most preferably stitches 16 should constitute a significant portion of that number of stitches per unit area. Both first stitches 10 and additional stitches 16 will pass through the glass fiber layer 6, and again additional organic fiber layer 12 will be essentially free, at least on its outer surface 15, of glass fibers displaced from glass fiber layer 6.

Figure 2 shows the fabric where the first stitches 10 pass at least substantially through the additional organic layer 12 and additional stitches 16 pass at least substantially through the organic fiber layer 2. This is a preferred embodiment, since it provides better physical properties to the composite fabric.

While not shown in the drawings, it will be readily apparent that the composite fabric lends itself to the modification where one or more further layers of glass fibers and/or organic fibers are disp sed adjacent to the outer surface 9 of the glass fiber layer 6 and these further layers like-

wise have stitches passing therethrough. However, in this regard it is preferred that where one or more such further layers of glass fibers and/or organic fibers are used, those further layers are disposed between organic fiber layer 2 and additional organic fiber layer 12 and likewise have stitches passing therethrough. This provides that all glass fiber layers and/or organic fiber layers, irrespective of how many are used, will be sandwiched between stitched organic fiber layers.

In regard to the fibers themselves, any of the conventional synthetic organic textile fibers may be used, e.g. thermoplastic fibers, and especially the conventional polyester fibers, acrylic fibers, polyamide fibers, including aramid fibers, polyvinyl chloride fibers, nylon fibers, poly (phenylene sulfide) fibers, polybenzoimidazole fibers and olefin fibers. Optionally, although not preferred the organic fibers may be natural fibers, e.g. wool, cotton, hemp. In addition, mixtures of the foregoing organic fibers may be used, although it is preferred that synthetic organic fibers be used in the organic fiber layer.

The glass fibers may be any of the conventional glass fibers, for example, the conventional vitrious glass fibers, C-glass fibers, S-glass fibers, E-glass fibers, air filtration-grade glass fibers, "range" grade fibers and the like, which glass fibers may or may not have a sizing thereon, e.g. a polysiloxane sizing.

The denier of the organic fiber is preferably between about 1.5 and 25 denier (0.16 and 2.77 tex), although more preferably that denier will be between about 2 and 15 denier (0.22 and 1.66 tex). The fiber length of the organic fiber may be from 1 to 4 inches (2.54 to 10.16 cm), although more usually the fiber length will be between 1.5 and 3 inches.

The glass fiber will have an average diameter of from about 1 micron up to about 25 microns, although more usually those fibers will have a diameter of from about 5 microns up to about 15 microns. The length of the glass fibers can vary substantially, since they do not substantially participate in the needling step, and may have lengths shorter than 1 millimeter up to as much as 10 millimeters, although more usually the length will be between 1 millimeter and 10 millimeters.

In a composite fabric having only one layer of organic fibers and only one layer of glass fibers, the weight ratio of the two layers may vary considerably. This is because the glass fibers do not participate in the needling step, as opposed to the above discussed U.S. Patent 3,975,565, where the layer of organic fibers has a small thickness compared with the thickness of the layer of inorganic fibers. This is a necessity in that patent, since the organic fiber layer cannot be sufficiently needled with only up to 260 needle punches per square inch to provide any substantial consolidation of the organic fibers, if the lay r of organic fibers has appreciable thickness (and hence amount of fibers therein). Therefore, in the present invention, the ratio of the weight of the organic fibers to th weight of the glass fibers can be from 1:10 to 10:1, and still a very good fabric can be obtained, but more usually, that ratio will be between 1:5 and 5:1.

Some variation in the ratio of glass fibers to organic fibers will be desirabl depending upon the particular end product desired. Further, the choice of the organic fibers will vary with the end product desired. Also, whether or not the glass fiber layer is sandwiched between two organic fiber layers will vary with the end product desired. Also, whether or not the glass fiber layer is sandwiched between two organic fiber layers will vary with the end product desired. Other variations will be apparent from the discussion below. For example, when the end product is intended to be a filter media, such as an air make-up filter, a clean room filter, a boiler filter and the like, the glass fiber layer is the primary filtration layer and it is important that the glass fiber layer, which can achieve fine filtration, be near the surface which first encounters the particles to be filtered. Such a filter is diagrammatically illustrated in Figure 3. Thus, a gas, e.g. air, to be filtered, shown by arrows 20, contacts a relatively thin organic fiber layer 21, which functions mainly as a containment for the glass fibers of glass fiber layer 22 and the essential filtration takes place by the glass fibers of the glass fiber layer 22. Additionally, simply for containment of the glass fibers, a second organic fiber layer 23 is provided for strength and containment, e.g. health, reasons.

Figure 4 shows a variation where the gas to be filtered (shown by arrows 20) first contacts a relatively thick organic fiber layer 25 where substantial filtration occurs, especially of more coarse particles, and then contacts glass fiber layer 26 where additional fine particle filtration takes place. Again, an organic fiber layer 27 is used primarily for strength and containment of the glass fibers in glass fiber layer 26.

Figure 5 illustrates a further application of the fabric of the invention. In this application, the fabric is not used as a filter, but as a heat insulator, for example, as a heat insulator to be placed between the floor board of an automobile and the carpet of an automobile in the passenger compartment of an automobile, so as to protect the feet of the passenger from heat generated by a catalytic converter underneath the floor board. In this case, the organic fiber layer 30 is relatively thin, and functions mainly as a strength component and containment of the glass fibers of glass fiber layer 31. Glass fiber layer 31 may not need a further organic fiber layer for containment of the glass fibers, since in this particular example, glass fiber layer 31 would abut the metal floor board and would be contained thereby. However, it could have an additional organic fiber layer to sandwich the glass fiber layer 31.

Th degree of needling in punches per unit area which approximately equates with the number of stitches per like unit area of organic fibers passing through the glass fiber layer, affects the detacha-

bility of the organic fiber layer from th glass fiber layer. Generally, if the numb r of such stitches per sq. cm is not at least 109 (700 per sq. in) then in some cases the layers are somewhat detachable from each other and the composite fabric is of lower physical properties. The term detachable, in this regard, means that the layers can detach from themselves in use, e.g. during flexing of a bag house filter made of the present fabric, or can be relatively easily manually detached by digitally tearing apart the layers. With about 109 stitches per sq. cm (700 per sq. in), the layers are generally substantially non-detachable, which means that the layers will not easily detached in either of the foregoing circumstances. However, to improve the non-detachability, it is preferred that the number of stitches per square cm be at least 156 (1000 per sq. in) e.g. 311 per cm^2 (200 per in^2) and for applications where substantially non-detachability is required, e.g. bag house filters, respirator filters, clean room filters, e.g. class 100 to class 1000, coal fired boilers filters, and the like, it is preferred that the stitches be at least 466 per cm^2 (3000 per in^2) and more preferably 776 to 1241 per cm^2 (5000 to 8000 per in^2). As will be appreciated from the foregoing, a major feature of this invention is the ability to place such large numbers of stitches through the glass fiber layer without substantially reorienting the fibers of that glass fiber layer (which reorientation could affect filtration properties and heat insulation properties) and without substantially breaking or degrading the glass fibers of the glass fiber layer.

Turning now to the details of the needling process to achieve the above needling, the needling may be carried out in any of the conventional needle looms, either single acting or double acting looms, but it is preferred that the needling be carried out with a double acting loom (needling from both sides) when sandwiching organic fiber layers are used, and more particularly with the known FIBERWOVEN® loom, which loom not only needles from both sides, but needles in increasing needle density needling stations and the needles penetrate the fabric at an angle to the plane of the fabric. This mode of needling, as achieved by a FIBERWOVEN® loom, is the preferred embodiment of the invention, and the best known mode.

The needles may vary considerably, but the blade of the needles may be between about 20 and 40 gauge with a regular barb, although a "formed" barb is preferred (a formed barb is smoothed, whereby it is less damaging to glass fibers). The needles may be single barbed or multiple barbed needles, but it is preferred to that when multi-barbed needles are used no more than 3 or 4 barbs per side of the needle is present.

The organic fiber layer may be prepared by carding a batt of organic fibers by ordinary carding machines. The glass fiber layer may be prepared by conventional laying mechanisms, e.g. air laying or wet laying, but since glass batts of this nature are commercially available, it is more convenient simply to obtain those batts from a commercial source. The batt of organic fibers and the batt of glass fibers may be laid in parallel, or cross-laid (cross-lapped) or combinations thereof. Since the glass fiber layer will not be substantially disturbed during the needling operation, this allows some design of the fabric by means of the laying of the batts. For example, since commercial glass fiber batts tend to be oriented in the direction of manufacture, e.g. air direction in air laying, the cross-laying of two or more glass fiber batts will achieve more random orientation of the glass fibers for better filtration and insulation properties.

On the other hand, the particular carding operation of the organic fibers can be important, depending upon the intended application of th fabric.

For example, the organic fiber batt to be needled into the organic fiber layer may be composed of multiple carded fibers where the last or top most carded fibers are of very fine denier. These fine denier fibers at the surface are not substantially picked up by the barbs of the needles during the needling operation, which would otherwise distribute the fine fibers throughout the organic fiber layer and through the stitches of the glass fiber layer, but instead leaves a layer of fine denier fiber relatively intact in its carded position. By maintaining the layer of fine fibers near the face surface or the needled fabric, the fine fibers disposed at or near the face surface greatly increase filtration efficiency and maintain face loading of a filtration fabric so that filtered particles can be easily dislodged therefrom, which is particularly important in bag house filters where dislodging of particles is by agitation. Nonetheless, there is sufficient needling of these fine fibers to intimately lock those fine fibers with the undercarded larger denier fibers in the organic fiber layer.

In order to provide the fabric of the present invention, as explained above in some detail, it is necessary to needle the fabric in such a manner that stitches of the organic fibers pass through the glass fiber layer, while at the same time the glass fiber layer is not substantially needled and left relatively undisturbed. It is an important feature of the invention and a most surprising discovery that such was even possible, when needling to the high number of needle punches per unit area required by the present fabric and especially when such needling is performed without substantially disturbing the glass fibers or breaking the glass fibers, as opposed to the experience disclosed in U.S. Patent 3,975,565, discussed above. However, once this surprising discovery was made, it was determined that needling of such characteristics could be carried out in a number of different manners. The needling need only provide a combination of needling factors, especially the factors of fiber characteristics, fiber batt depth, needle barb size, number f barbs, needle barb penetration and needl barb configuration such that the barbs of the needles, and especially the first barb, are essentially fully

loaded during passage through the organic fiber layer, or are loaded in a configuration, such that the fine diameter glass fibers cannot be substantially picked up by the needle barbs. While these factors admit to a great number of possible permutations, a selection of th possible permutations can be made such that with any particular groups of those factors, relatively few experiments will be required in order to find combinations of those factors which will produce the present needling. Thus, if a particular needle barb size and configuration is desired, for example, where the needle is already disposed in a conventional loom, then the particular organic fiber can be changed, or the denier of the fibers, or the length of the fibers, or the depth of the fiber batt can be changed until one of these combinations produces the present needling. On the other hand, if a particular organic fiber is desired, then the length of that fiber, the denier of that fiber, and the depth of the fiber batt can be changed until the present needling is achieved.

On the other hand, if a particular organic fiber of a certain denier and certain length is desired, then the barb configuration, size, depth and penetration, as well as the batt thickness can be changed until the present needling is achieved.

The only caveat to the foregoing is that in all cases, it is preferred that the needling be conducted in a manner where the initial stages of needling are designed such that less agressive needling takes place, and in successive stages of needling more agressive needling takes place. Those skilled in the art know how to design such increasing agressiveness of needling, but briefly stated, the agressiveness of needling depends upon prior compaction, e.g. roller compaction, of the batt to be needled, the number of needles displayed per square inch in a particular needling stage needling board, the size and configuration of the needle barb or barbs, and the depth of penetration of the needle barbs. Substantial compaction prior to needling is not normally either necessary or desirable and usually the compaction, e.g. by rollers, will be only to the extent of providing the batts in a thickness which is satisfactory for conveniently entering the first needling station of the particular looms being used.

Standard needle catalogues and like descriptions identify particular needle barb configurations for relative agressiveness, especially toward different fibers and less aggressive needles may be easily chosen. However, usually the needles should not have more than 3 or 4 barbs along the blade of the needle on any one barb surface. For example, if a triangular blade needle is used, it should not have more than 3 or 4 barbs along each barbed edge of the triangled blade.

The barb configuration will normally be either a "regular" barb or a "formed" barb, especially as opposed to the agressive "projecting" barbs (which project from the blade), e.g. as illustrated in U.S. Patent 3,608,166. Regular barbs are disposed primarily within the blade and formed barbs are likewise disposed but additionally smoothed to be less aggressive. Barb depths will generally be smaller as opposed to the large depths for ne dling coarse fibers.

The penetration of the first barb of the needle will be substantially through the batts being needled up to about 6.35 to 8.89 mm (0.25 to 0.35 inch) beyond the pposite side of the batts from that side that the needles enter the batts. Penetration much beyond this gives too aggressive needling, particularly in the earlier needling and with more aggressive needles.

The display of needles in the needle boards affect the aggressiveness of needling. The greater the number of needles per square inch which penetrate the batt per stroke of a needle board, the more aggressive the needling. This is because more fibers are engaged by the larger number of needles during any one stroke and hence there is less fiber mobility and less opportunity for fibers to slip out of an engaging barb.

With fewer numbers of needles per square inch per stroke, fiber mobility is greater and more fibers can slip out of engaging barbs, i.e. less aggressive needling. Likewise if the barbs are, for example, formed barbs, the fibers can more easily slip out of an engaging barb and less aggressive needling takes place. Accordingly, the present needling should be conducted with numbers of needles per square inch per stroke and/or barb configuration and/or barb penetrations where less aggressive needling takes place.

The foregoing may also be adjusted for the ultimate number of needle punches per square inch which is desired. Hence, if a lower density fabric is desired, e.g. as a heat insulator then, for example, only 156 needle punches per cm^2 (1000 per in^2) may be used.

This can be achieved in a single needling station (two opposed needle boards) of a FIBERWOVEN® loom and all with the same needles. However, if a large number of needle punches per unit area is desired, e.g. for a bag house filter, then the number of needles per stroke in the earlier needling stages may be reduced with high numbers of needle punches per square inch in the latter needling stages. Alternatively, low aggressive needles may be used with the same numbers of needles in each needling stage and a large total number of needle punches is used to provide the required fiber intanglement for a strong fabric. For example, one or more FIBERWOVEN® looms may be used with each needle board of the 4 needling stages substantially full of the same needles, and the present fabric will still result when low aggressive needles are used and the number of needle punches per cm^2 is at least 311 to 466 per cm^2 (2000—3000 per in^2) or more preferably 466 to 620 per cm^2 (3000—4000 per in^2).

All of the above is designed to produce the present type of needling. Basically this type of needling insures that the fiber engaging barbs of the needl s are substantially loaded with rganic fibers before penetrating the glass fiber layer or are so loaded with organic fibers that engaged

glass fibers can easily slip out of the so loaded barbs. Thus, the glass fiber layer is substantially undisturbed during needling while the organic fiber layer is fully needled.

The resulting fabrics have a wide variety of uses. Thus, the fabric may be in the form of a filter, e.g. a bag house filter with organic fiber to glass fiber weight ratios of 4:1 to 12:1 or a breather filter with such ratios of 5:1 to 3:1, or an insulator, e.g. a heat insulator, with such ratios of 1:4 to 10:1. The fabric may also be in the form of a drapery material, heat protective clothing, and sound absorbing coverings.

The needled fabric may be sized or coated or filled or impregnated in a variety of manners as is common to the art. Thus, polytetrafluoroethylene sizes may be padded on and cured. Alternatively, polyacrylic sizings or other polymeric or natural sizings may be used. Fillers, e.g. kaolin, talc, etc. may be padded in the fabric. Coatings, e.g. polyethylene, acrylic and polyester coatings may be applied. Foam coatings, either in the expanded or crushed state, may be provided on the fabric. The fabric may be impregnated with a resin and cured to provide a more rigid structure, e.g. impregnated with an epoxie or polyester.

The surface of the fabric may be finished in conventional manners, e.g. calendering, glazing, heat singeing. The glass layer may be placed in the batts for needling either alone or carried on a carrier, e.g. a light weight woven or non-woven scrim.

In addition the fabric may be combined with another fabric. For example, where a relatively thick fabric is desired, e.g. an insulating mat, the present fabric may be tacked to an inexpensive carrier fabric. e.g. a jute or cotton non-woven mat, or such a mat may be fed through the needling process and the present fabric and the mat are *in situ* attached. In lieu of a mat woven or knitted fabric may be used.

The invention is illustrated by the following examples, where all percentages and parts are by weight, unless otherwise specified, as is also the case in the foregoing disclosure and following claims.

Example 1

Three carding machines carded 101.8 g/m^2 (3 ounces per square yard) each of poly(phenylene sulfide) staple fibers (Ryton® PPS—Phillips Petroleum Co.) into a cross-lapped batt of 305.4 g/m^2 (9 ounces per square yard) total weight. The staple fibers were crimped, had an average length of about 5 cm (2 inches) and an average denier of about 3. Between the top and middle cards was fed a woven scrim of poly(phenylene sulfide) having 3 to 4 picks per cm (8 to 10 picks per inch) and an open weave. The scrim carried about 61.09 g/m^2 (1.8 ounces per square yard) of Air Filtration grade 11 glass fiber batt (Johns-Manvill). The carded staple fibers and the scrim carried glass fibers were collected and moved on a floor apron and an inclined apron to a series of three FIBER-WOVEN needle looms, each with 4 needling stations and 2 needle boards per station. Each needle board was provided with relatively low aggressive FOSTER 3-40-4-A needles (40 blade gauge). The needle density per board was such that in traversing the three looms the resulting fabric had been needl punched about 931 punches per cm^2 (6000 per square inch).

The resulting fabric had an overall bulk density of about 96 kg/m^3 (6 lbs. per cubic foot). The layer of glass fibers was sandwiched between a top thinner layer of poly(phenylene sulfide) fiber fabric (about 101.8 g/m^2 (3 oz. per square yard) and a thicker bottom layer of poly(phenylene sulfide) fiber fabric (about 237.5 g/m^2) (almost 7 oz. per square yard)—including the scrim). The glass fiber layer was quite distinct and visually (side view) separate from the sandwiching fabric layers. The sandwiching fabric layers were quite difficult to manually tear from the glass fiber layers, and in attempting to manually separate these layers, it was visually observed that there were thousands of stitches of poly(phenylene sulfide) fibers through the glass fiber layer per square inch. There were essentially no glass fibers on the outer surfaces of the poly(phenylene sulfide) fibers layer. The glass fibers layer was essentially unneedled, except that there was substantially intertwining between the glass fiber layer and the two poly(phenylene sulfide) fibers layers.

The fabric was padded to 0.5% add-on with an aqueous fluoropolymer dispersion sizing (Teflon®-B-PTFE-DuPont), cured in a heated oven at 204°C (400°F) for 4 minutes and calendered on hot cans at 204°C (400°F) with can pressure sufficient to reduce the thickness of the fabric to 0.165 cm (65 mils). The surface of the fabric was smooth.

The cured fabric was tested for air permeability and had a Frazier of between 850 and 1133 l. per minute (30 and 40 CFM). The smooth surface allowed collected "cake" to be easily released when used as a filter and the fluorocarbon sizing improves abrasion resistance, chemical resistance and flex endurance. The poly(phenylene sulfide) fibers of 191°C (375°F) working temperature, 204°C (400°F) intermittant temperature and H_2SO_4 resistant allow this fabric to very satisfactorily function as a bag house filter for a coal fired boiler.

Example 2

The procedure of Example 1 was repeated except that in lieu of the poly(phenylene sulfide) fibers, 5 cm (2 inch), 3 denier, crimped polyester fibers were used, and no sizing was placed on the needled fabric. The fabric had a Frazier Air Permeability of between 1133 and 1417 l. per minute (40 and 50 CFM), but was otherwise similar to the fabric of Example 1 prior to sizing. This fabric functions satisfact rily as an air filter, or a prefiller for a clean room filter.

Example 3

Two carding machines carded 50.9 g (1.5 ounces) each of an aramid staple fibers (Nomex®) on

the apron system of Example 1 into cross-lapped batts. A batt of "range-type" glass fibers (Owen-Corning HT-26-K valve 26), with a weight of about 475 g/m² (14 ounces per square yard), was fed between the carded batts of aramid fibers. These batts were needled in a FIBERWOVEN lo m using FOSTER-5 needles which are less aggressive needles, and only one needling station to provide about 109 needle punches per cm² (700 per square inch). The needled fabric was about 15 mm (0.6 inch) thick. The layers were not easily manually separated and the stitching described in Example 1 was observed. The fabric K-value was less than 0.26 at 24°C and 0.31 at 93°C. The heat transfer from a 175°C hot face gave a constant temperature of 110°C on the cold face. The glass fiber layer was essentially undisturbed, but the aramid fiber layer was satisfactorily strong.

This insulator fabric functioned satisfactorily as a heat insulator between the carpet and metal floor board of an automobile when placed over the catalytic converter and essentially no glass fibers were on the outer surface of the aramid fiber layer.

Example 4

Two carding machines carded 101.8 g/m² (3 ounces per square yard) each of 6 denier, 5 cm (2 inches) crimped polyester fibers on the apron system of Example 1 into a cross-lapped batt. Between the two cards was fed 61.09 g/m² (1.8 ounces per square yard) of Air Filtration grade 11 glass fiber batt (Johns-Manville) carried on a spun bonded polyester scrim. The needling of Example 3 was repeated except that two such needling stations were used and the fabric was needle punched about 217 punches per cm² (1400 per square inch). The glass fiber layer was essentially unneedled but the polyester fiber layer was needled into a relatively strong layer with essentially no glass fibers on its outer surface.

The fabric functioned satisfactorily as an ASHRAE Type Air Filter (American Society of Heating Refrigeration and Airconditioning Engineers).

Example 5

A batt was prepared from approximately 101.8 g/m² (3 ounces per square yard) of the polyester fibers of Example 1 and approximately 101.8 g/m² (3 ounces per square yard) of the glass fibers of Example 3. Needling of the batt was performed in a single station of a FIBERWOVEN loom with only one needle board in the station and with the needles of Example 1 to achieve approximately 109 needle punches per cm² (700 per square inch). In test A the needling was from the glass fiber batt and in test B the needling was from the polyester fiber batt. The fabric which resulted from test A, could be easily manually torn apart with only the lightest pull at the interface of the glass and polyester fibers layers. The stitches of glass fibers into the polyester layer were weak (partially broken fibers) and glass fibers (partially broken) were on the outside surface of the p lyester layer. The fabric was not satisfactory.

In test B, the needling was the same as test A, but from the polyester fiber layer. The glass and polyester fiber layers could be torn apart manually only with a significant pull and there were no glass fibers on the outside surface of the polyester layer. This relatively lightly needled fabric is quite satisfact ry for some purposes, e.g. lightly stressed filters.

Claims

1. An integral textile composite fabric of non-woven, needled textile fibers comprising:

(a) at least one organic textile fiber layer of laid textile organic fibers;

(b) at least one glass fiber layer of laid, uncrimped glass fibers;

(c) a plurality of first needled stitches binding the said layers together and composed essentially of said organic fibers from said organic fiber layer needled in and disposed substantially through said one glass fiber layer while the fibers of the said glass fiber layer are substantially undisturbed, and wherein said one organic fiber layer is essentially free, at least on the outer surface thereof, of glass fibers displaced from said one glass fiber layer.

2. The fabric of claim 1 wherein an additional organic fiber layer of textile organic fibers is disposed next to an outer surface of said one glass fiber layer, and the said stitches are also so disposed in said additional organic fiber layer that said additional organic fiber layer is likewise bound to an outer surface of said one glass fiber layer.

3. The fabric of claim 2 wherein a plurality of additional stitches composed essentially of organic fibers from said additional organic fiber layer are needled in and disposed substantially through said one glass fiber layer so that said additional organic fiber layer is bound to said one glass fiber layer, and wherein said additional organic fiber layer is also essentially free, at least on the outer surface thereof, of glass fibers displaced from said one glass fiber layer.

4. The fabric of claim 3 wherein the said first binding stitches pass at least substantially through said additional organic fiber layer and said additional stitches pass at least substantially through said one organic fiber layer.

5. The fabric of any preceding claim, wherein one or more further layers of glass fibers and/or organic fibers are disposed adjacent to the outer surface of the one glass fiber layer and said further layers likewise have stitches passing therethrough.

6. The fabric of any preceding claim, wherein the amount of stitches is at least 109 per cm² (700 per in²).

7. The fabric of claim 6, wherein the amount of stitches is at least 156 per cm² (1000 per in²).

8. The fabric according to any preceding claim wherein the weight ratio of organic fiber to glass fiber is 4:1 to 12:1.

9. The fabric according to any one of claims 1 to

7, wherein the weight ratio of organic fibers to glass fibers is 5:1 to 3:1.

10. The fabric according to any one of claims 1 to 7 wherein the ratio of organic fiber to glass fiber is 1:4 t 1:10.

11. The use of the fabric according to any one of claims 1 to 8 as a filter.

12. The use of the fabric according to claim 8 as a bag house filter.

13. The use of the fabric according to any one of claims 1 to 7 and 10 as an insulator.

14. The use of the fabric according to claim 10 as a heat insulator.

15. The use of the fabric according to claim 9 as a breathing filter.

16. The fabric of any one of claims 1 to 10 which has one or more of a coating thereon, a sizing thereon, a filler therein and an impregnating resin therein.

17. The fabric of any one of claims 1 to 10 and 16 attached to a carrier fabric.

18. The fabric of any one of claims 1 to 10, 16 and 17 having a surface finish.

19. A process for the production of the fabric of any one of claims 1 to 10, comprising:

(1) preparing a laid glass fiber batt of said glass fibers;

(2) preparing a laid organic fiber batt of said organic fibers;

(3) placing the said batts adjacent to each other to form a composite batt;

(4) binding said batts together by needling from the side of the organic fiber layer so that stitches composed essentially of said organic fibers from said organic fiber layer are needled in and disposed substantially through said glass fiber layer while the fibers of the said glass fiber layer are substantially undisturbed.

20. The process of claim 19 wherein there is more than one organic fiber layer and the organic fiber layers sandwich the glass fiber layer.

21. The process of claim 20 wherein there is more than one glass fiber layer.

22. The process of claim 19, 20 or 21 wherein the aggressiveness of the needling is such that said glass fiber layer(s) is/are substantially undisturbed during said needling.

23. The process of claim 22 wherein the aggressiveness of the needling is controlled by one or more of the following parameters: needle barb size, depth, configuration and penetration and organic fiber length, denier and composition.

Patentansprüche

1. Integrales, zusammengesetztes Textilmaterial aus ungewebten, genadelten Textilfasern, mit

(a) mindestens einer organischen Textilfaserschicht aus gelegten textilen organischen Fasern;

(b) mindestens einer Glasfaserschicht aus gelegten, ungekräuselten Glasfasern;

(c) einer Mehrzahl von ersten genadelten Stichen, die die beiden Schichten miteinand r verbinden und im wesentlichen organischen Fasern aus der organischen Faserschicht in und im wesentlichen durch die Glasfaserschicht nadeln, während die Fasern der Glasfaserschicht im wesentlichen ungestört bleiben, und wobei die eine organische Faserschicht zumindest an ihrer äußeren Oberfläche im wesentlichen frei von Glasfasern ist, die aus der einen Glasfaserschicht verlagert sind.

2. Material nach Anspruch 1, bei dem eine zusätzliche organische Faserschicht aus textilen organischen Fasern an der äußeren Fläche der einen Glasfaserschicht vorgesehen ist und bei der die Stiche sich auch in die zusätzliche organische Faserschicht erstrecken, so daß die zusätzliche organische Faserschicht in gleicher Weise mit einer äußeren Fläche der einen Glasfaserschicht verbunden ist.

3. Material nach Anspruch 2, bei dem eine Vielzahl von zusätzlichen, im wesentlichen organische Fasern aus der zusätzlichen organischen Faserschicht umfassende Stiche in die eine Glasfaserschicht genadelt und im wesentlichen durch diese geführt sind, so daß die zusätzliche organische Faserschicht mit der einen Glasfaserschicht verbunden ist, und wobei die zusätzliche organische Faserschicht ebenfalls zumindest an ihrer äußeren Oberfläche frei von Glasfasern ist, die aus der einen Glasfaserschicht verlagert sind.

4. Material nach Anspruch 3, bei dem die ersten Bindungsstiche sich zumindest im wesentlichen durch die zusätzliche organische Faserschicht und die zusätzlichen Stiche sich zumindest im wesentlichen durch die eine organische Faserschicht erstrecken.

5. Material nach einem der vorhergehenden Ansprüche, bei dem eine oder mehrere weitere Schichten aus Glasfasern und/oder organischen Fasern benachbart zu Außenfläche der einen Glasfaserschicht angeordnet sind und sich nt-sprechend Stiche durch die weiteren Schichten erstrecken.

6. Material nach einem der vorhergehenden Ansprüche, bei dem die Anzahl der Stiche mindestens 109 pro cm^2 (700 pro in^2) beträgt.

7. Material nach Anspruch 6, bei dem die Anzahl der Stiche mindestens 156 pro cm^2 (1000 pro in^2) beträgt.

8. Material nach einem der vorhergehenden Ansprüche, bei dem das Gewichtsverhältnis von organischen Fasern zu Glasfasern 4:1 bis 12:1 beträgt.

9. Material nach einem der Ansprüche 1 bis 7, bei dem das Gewichtsverhältnis von organischen Fasern zu Glasfasern 5:1 bis 3:1 beträgt.

10. Material nach einem der Ansprüche 1 bis 7, bei dem das Verhältnis von organischen Fasern zu Glasfasern 1:4 bis 1:10 beträgt.

11. Verwendung des Materials gemäß einem der Ansprüche 1 bis 8 als Filter.

12. Verwendung des Materials gemäß Anspruch 8 als Filterkammerbeutel.

13. Verwendung des Materials gemäß einem der Ansprüche 1 bis 7 sowie 10 als Isolierung.

14. Verwendung des Materials gemäß Anspruch 10 als Wärm isolierung.

15. Verwendung des Materials gemäß

Anspruch 9 als Atemfilter.

16. Material nach einem der Ansprüche 1 bis 10, auf dem sich eine oder mehrere Beschichtungen und eine Appretur und in dem sich ein Füllstoff und ein Imprägnierharz befinden.

17. Material nach einem der Ansprüche 1 bis 10 sowie 16, das mit einem Trägermaterial verbunden ist.

18. Material nach einem der Ansprüche 1 bis 10, 16 und 17 mit einer Oberflächenausrüstung.

19. Verfahren zur Herstellung des Materials gemäß einem der Ansprüche 1 bis 10, umfassend:

(1) Herstellung einer gelegten Glasfaserlage aus den Glasfasern;

(2) Herstellung einer gelegten organischen Faserlage aus den organischen Fasern;

(3) Zusammenlegen der Lagen zur Bildung einer zusammengesetzten Lage;

(4) Verbinden der Lagen miteinander durch Nadeln von der Seite der organischen Faserschicht, so daß im wesentlichen organische Fasern aus der organischen Faserschicht aufweisende Stiche in die Glasfaserschicht und im wesentlichen durch diese genadelt werden, während die Fasern der Glasfaserschicht im wesentlichen ungestört bleiben.

20. Verfahren nach Anspruch 19, bei dem mehr als eine organische Faserschicht verwendet wird und die Glasfaserschicht zwischen den organischen Faserschichten liegt.

21. Verfahren nach Anspruch 20, bei dem mehr als eine Glasfaserschicht eingesetzt wird.

22. Verfahren nach Anspruch 19, 20 oder 21, bei dem die Aggressivität der Nadelung so ist, daß die Glasfaserschicht(en) während der Nadelung im wesentlichen ungestört bleibt/bleiben.

23. Verfahren nach Anspruch 22, bei dem die Aggressivität der Nadelung durch einen oder mehrere der folgenden Parameter gesteuert wird: Nadelhakengröße, Tiefe, Form und Eindringung und Länge der organischen Fasern, Titer und Zusammensetzung.

Revendications

1. Nappe composite textile intégrale en fibres textiles aiguilletées non tissées comprenant:

a) au moins une couche de fibres textiles organiques en fibres organiques textiles déposées,

b) au moins une couche de fibres de verre en fibres de verre non frisées.

c) une pluralité de premières piqûres d'aiguilles liant ensemble lesdites couches et composées essentiellement desdites fibres organiques venant de ladite couche de fibres organiques enfoncées par des aiguilles et disposées substantiellement à travers ladite couche de fibres de verre cependant que les fibres de cette dernière couche sont substantiellement non dérangées, et dans laquelle ladite couche de fibres organiques est essentiellement exempte, au moins à sa surface extérieure, de fibres de verre déplacées de ladite couche de fibres de verre.

2. Nappe de la revendication 1, dans laquelle une couche additionnelle de fibres organiques est disposée à proximité d'une surface extérieure de ladite couche de fibres de verre, et lesdites piqûres sont aussi disposées dans cette couche additionnelle de fibres organiques de telle sorte que cette d rnière couche est pareillement liée à une surface xtérieure de ladite couche de fibres de v rre.

3. Nappe de la revendication 2, dans laquelle une pluralité de piqûres additionnelles composées essentiellement de fibres organiques venant de ladite couche additionnelle de fibres organiques ont été enfoncées par des aiguilles et sont disposées substantiellement à travers ladite couche de fibres de verre de telle sorte que cette couche additionnelle est liée à cette couche de fibres de verre, et dans laquelle ladite couche additionnelle de fibres organiques est aussi essentiellement exempte, au moins à sa surface extérieure, de fibres de verre déplacées de ladite couche de fibres de verre.

4. Nappe de la revendication 3, dans laquelle lesdites premières piqûres de liaison passent au moins substantiellement à travers ladite couche additionnelle de fibres organiques et lesdites piqûres additionnelles passent au moins substantiellement à travers ladite couche de fibres organiques.

5. Nappe selon l'une quelconque des revendications précédentes dans laquelle une ou plusieurs couches supplémentaires de fibres de verre et/ou de fibres organiques sont disposées à la surface extérieure de ladite couche de fibres de verre et ces couches supplémentaires ont pareillement des piqûres qui les traversent.

6. Nappe selon l'une quelconque des revendications précédentes dans laquelle la quantité de piqûres est au moins de 109 par cm^2 (700 par pouce^2).

7. Nappe de la revendication 6, dans laquelle la quantité de piqûres est au moins de 156 par cm^2 (1000 par pouce^2).

8. Nappe selon l'une quelconque des revendications précédentes dans laquelle le rapport en poids des fibres organiques aux fibres en verre est de 4:1 à 12:1.

9. Nappe selon l'une quelconque des revendications 1 à 7, dans laquelle le rapport en poids des fibres organiques aux fibres en verre est de 5:1 à 3:1.

10. Nappe selon l'une quelconque des revendications 1 à 7, dans laquelle le rapport des fibres organiques aux fibres en verre est de 1:4 à 1:10.

11. Utilisation de la nappe selon l'une quelconque des revendications 1 à 8 en tant que filtre.

12. Utilisation de la nappe selon la revendication 8 en tant que filtre dans une chambre de filtration d'un filtre à poches.

13. Utilisation de la nappe selon l'une quelconque des revendications 1 à 7 et 10 en tant qu'isolant.

14. Utilisation de la nappe selon la revendication 10 en tant qu'isolant thermique.

15. Utilisation de la nappe selon la revendication 9 en tant que filtre respiratoire.

16. Nappe selon l'une quelconque des revendi-

cations 1 à 10 qui a sur elle un ou plusieurs revêtements, un imperméabilisant, intérieurement une charge et une résine d'imprégnation.

17. Nappe selon l'une quelconque des revendications 1 à 10 et 16 attachée à une étoffe port use.

18. Nappe selon l'une quelconque des revendications 1 à 10, 16 et 27 ayant un fini de surface.

19. Procédé pour la fabrication de la nappe de l'une quelconque des revendications 1 à 10, comprenant:

1) la préparation d'un matelas de fibres de verre déposées en fibres de verre,

2) la préparation d'un matelas de fibres organiques déposées en fibres organiques,

3) le placement de ces matelas au voisinage l'un de l'autre pour former un matelas composite.

4) la liaison de ces matelas ensemble par aiguilletage à partir du côté de la couche de fibres organiques de telle sorte que des piqûres composées essentiellement de ces fibres organiques venant de cette couche de fibres organiques sont enfoncées par les aiguilles et disposées substantiellement à travers la couche de fibres de verre cependant que les fibres de cette couche de fibres de verre sont substantiellement non dérangées.

20. Procédé de la revendication 19, selon lequel il existe plus d'une couche de fibres organiques et les couches de fibres organiques contiennent entre elles la couche de fibres de verre.

21. Procédé de la revendication 20, selon lequel il existe plus d'une couche de fibres de verre.

22. Procédé des revendications 19, 20 ou 21, selon lequel l'agressivité de l'aiguilletage est telle que ladite ou lesdites couches de fibres de verre est ou sont substantiellement sans dérangement pendant cet aiguilletage.

23. Procédé de la revendication 22, selon lequel l'agressivité de l'aiguilletage est contrôlée par un ou plusieurs des paramètres suivants: pénétration, configuration, profondeur et dimension des barbes des aiguilles et composition, grosseur et longueur des fibres organiques.

FIG. 1

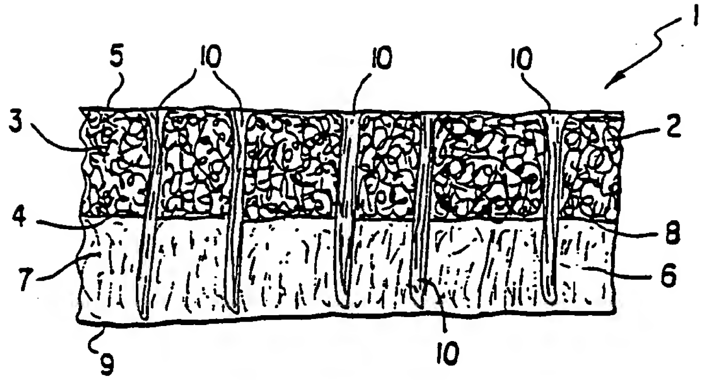
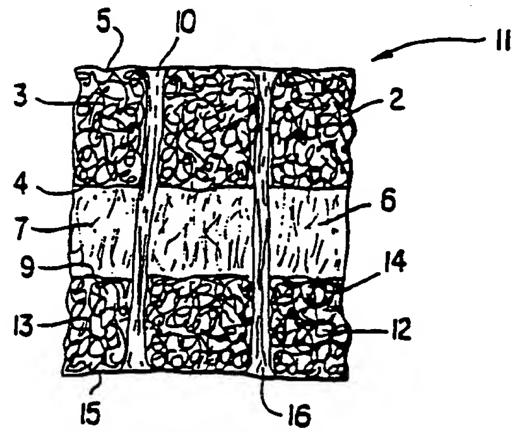


FIG. 2



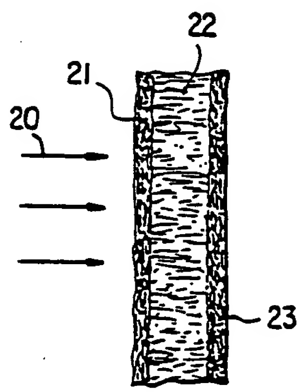


FIG. 3

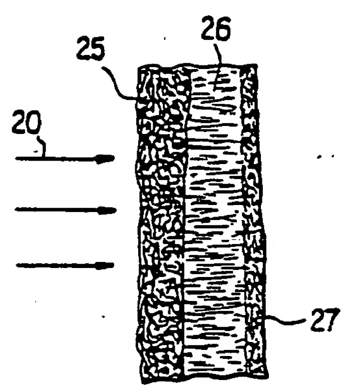


FIG. 4

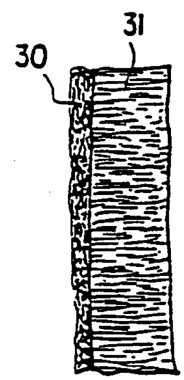


FIG. 5